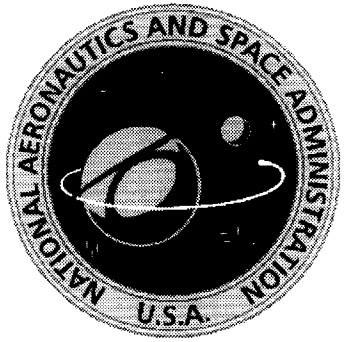
National Polar-orbiting Operational Environmental Satellite System



May 2, 1996

NPOESS Program Objectives

- To provide a single national remote sensing capability to acquire, receive and disseminate global and regional weather data. These data include imagery, specialized meteorological, climatological, terrestrial, oceanographic, and solar-geophysical information

- To achieve National Performance Review (NPR) cost-savings through the convergence of DoD and NOAA meteorological satellite programs

- To incorporate, where appropriate, technology transition from NASA EOS program

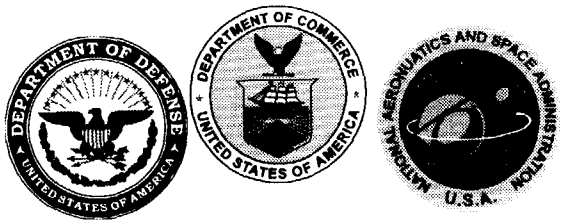
Memorandum of Agreement

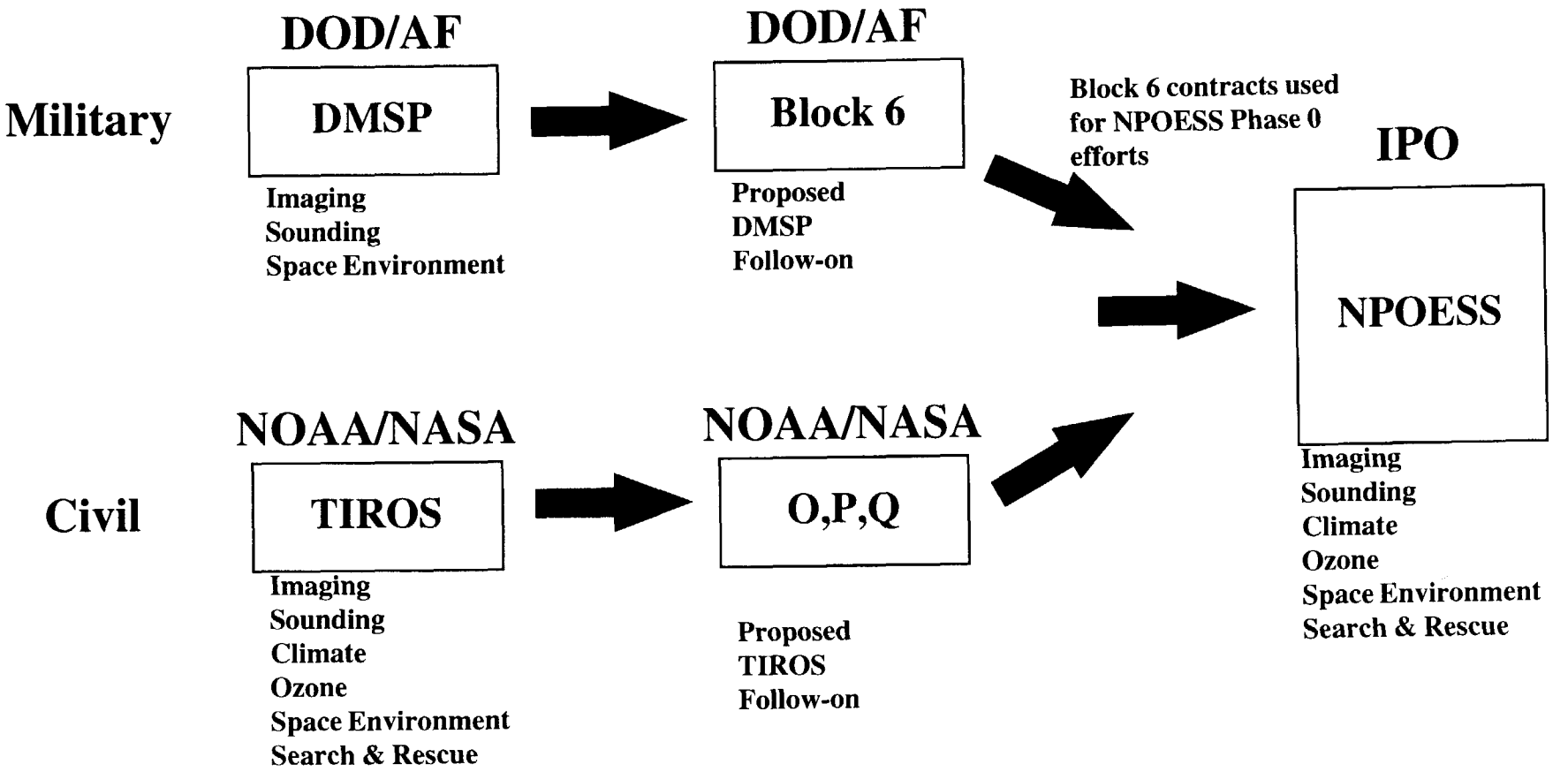
- **Tri-agency MOA Signed in May 95, Establishes Executive Committee (EXCOM)**
  - **Under Sec'y of Commerce for Oceans & Atmosphere, Dr. D. J. Baker**
  - **Under Sec'y of Defense (Acquisition & Technology), Dr. P. G. Kaminski**
  - **NASA Deputy Administrator, J. R. Dailey, Gen (Retired)**

  – **DOC and DoD committed to jointly provide total of approximately $1.4B in FY96-01 for NPOESS acquisition**

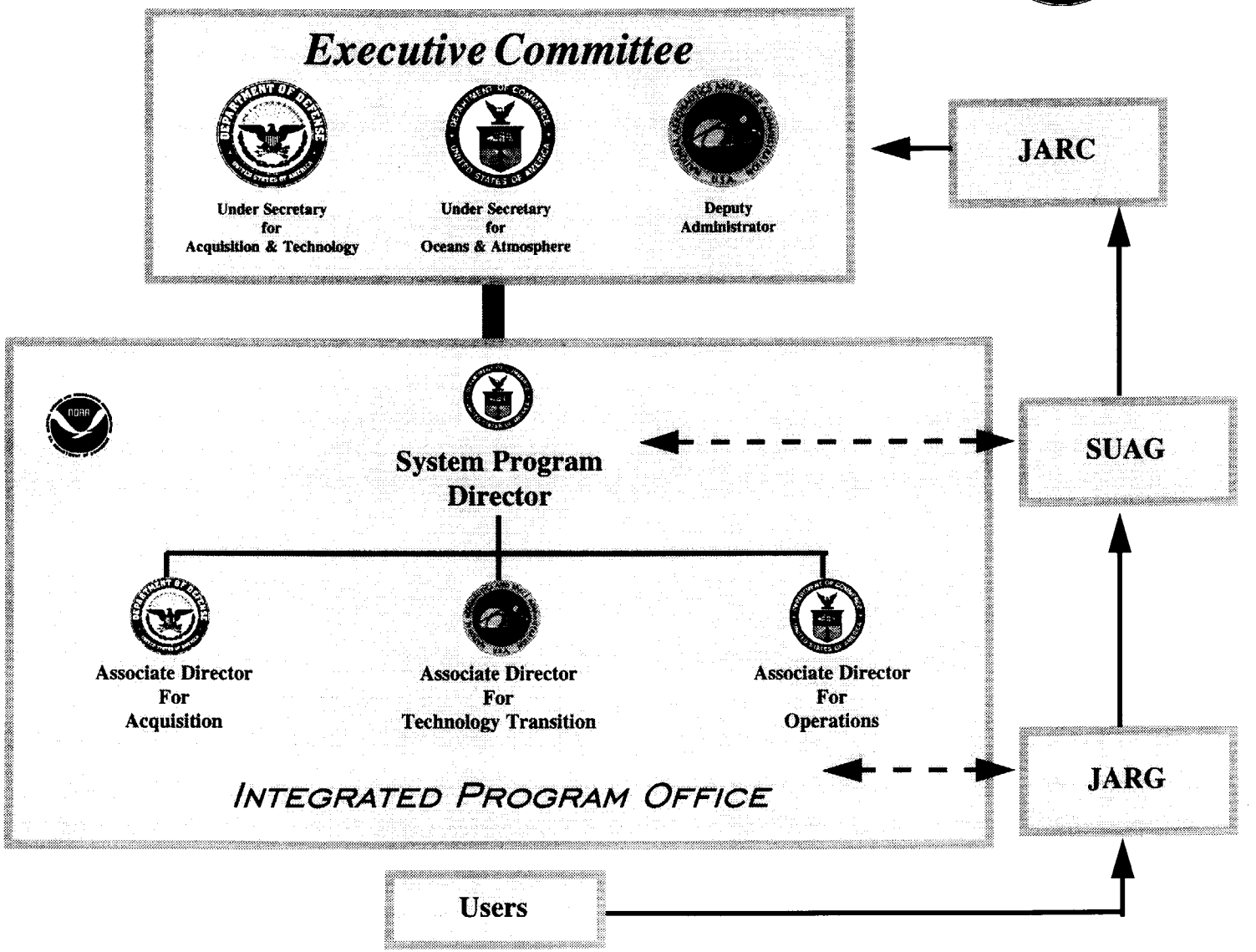
  – **MOA defines roles and responsibilities**
    - **DOC is lead agency for program execution and operations**
    - **DoD is lead agency for acquisition**
    - **NASA is lead agency for technology transition**
  – **Recognizes involvement of international community**

Program Evolution

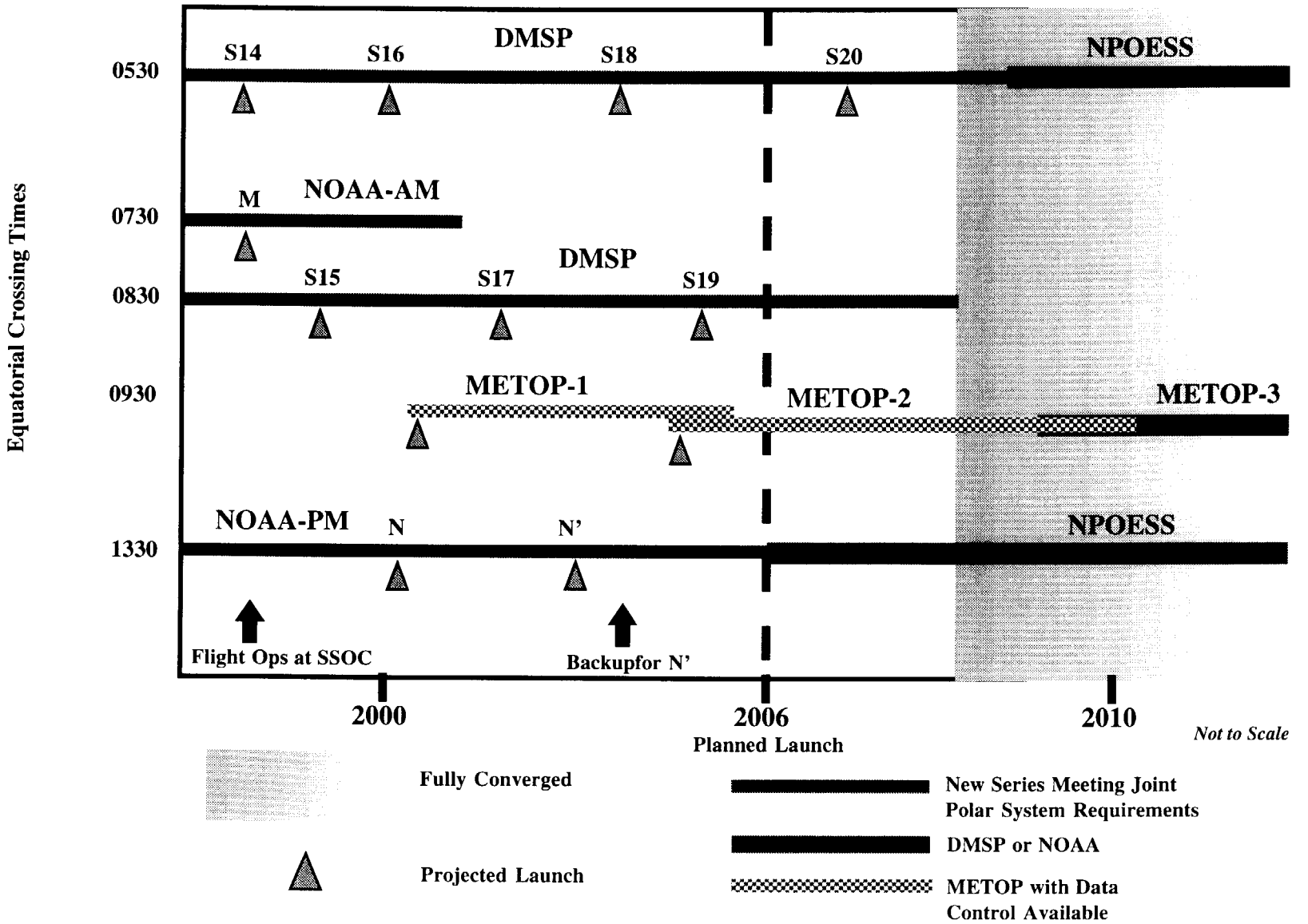




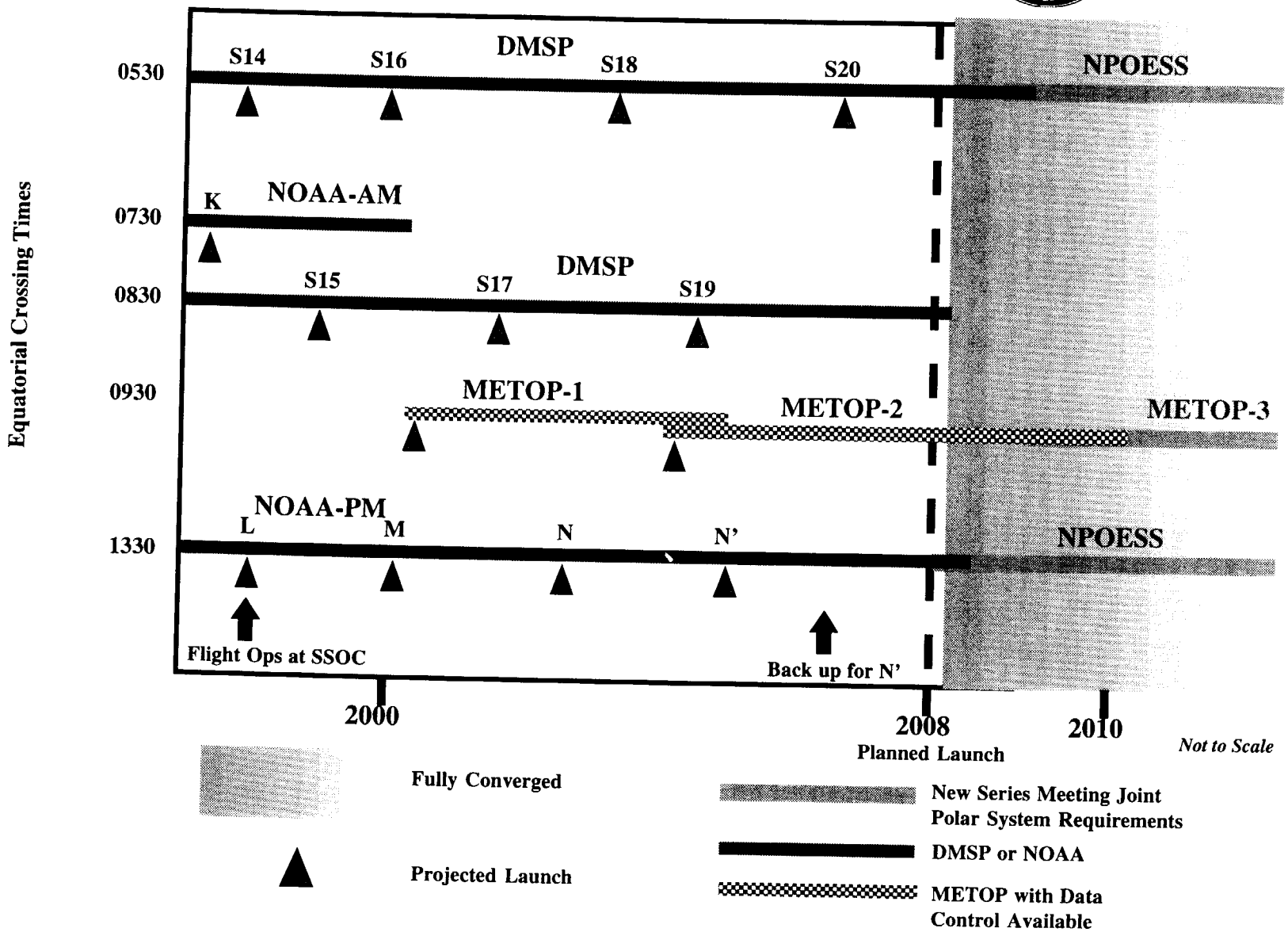
Organizational Relationships



Flight Vehicle Synchronization



Optimized Convergence Flight Vehicle Synchronization



Requirements Players

- **Joint Agency Requirements Group (JARG)**
  - Developed the Tri-agency Integrated Operational Requirements Document (IORD)
  - Prioritize, harmonize, & document operational requirements
- **Senior Users Advisory Group (SUAG)**
  - Represent the primary USG users
  - Advise the SPD on user community needs
  - Select the preferred solution
- **Joint Agency Requirements Council (JARC)**
  - Senior interagency body to approve NPOESS IORD
  - Principals: Vice Chairman JCS, Deputy Under Secretary of Commerce for Oceans and Atmosphere, NASA Associate Administrator for Mission to Planet Earth

Notional System Architecture

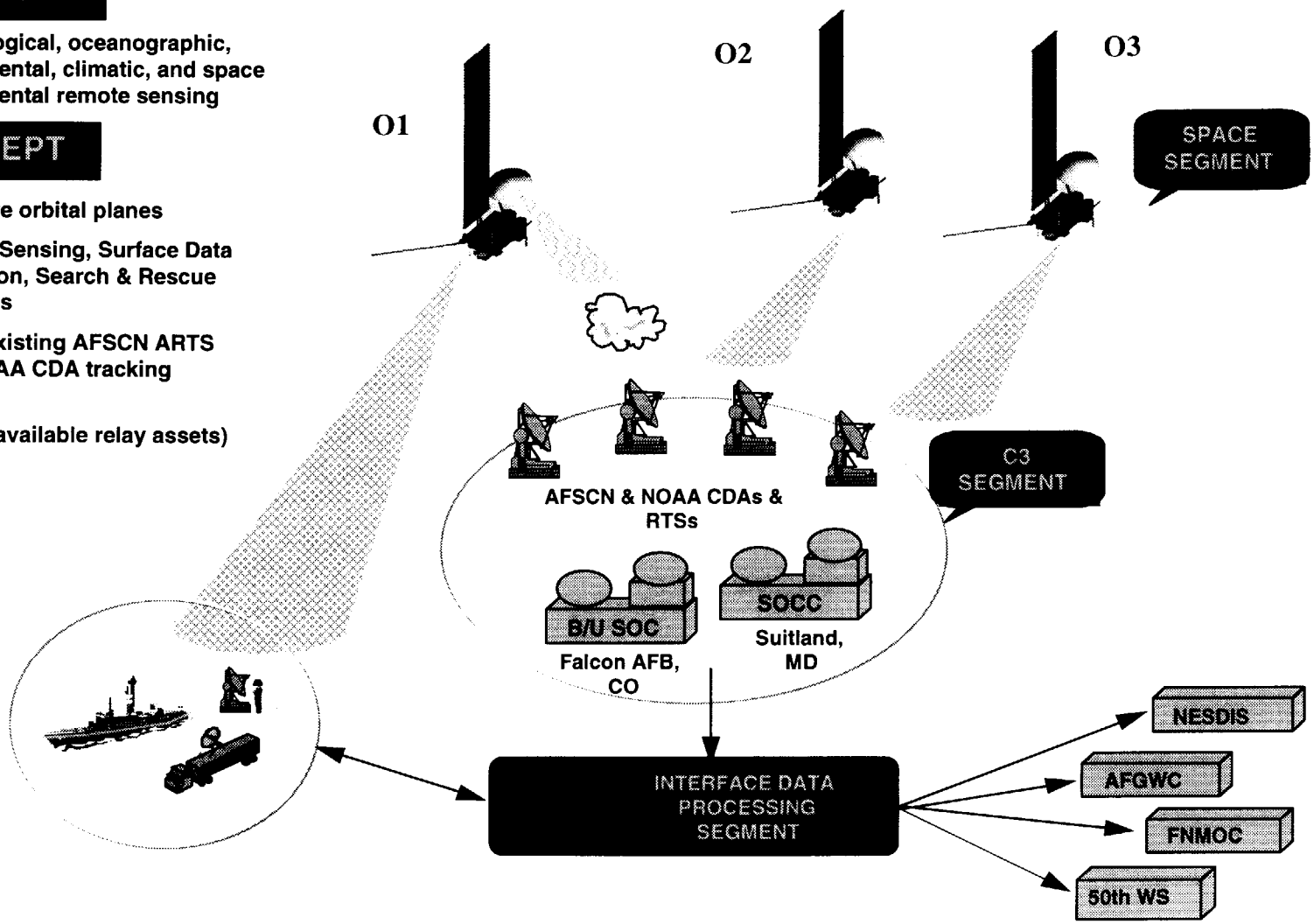
MISSION

Meteorological, oceanographic, environmental, climatic, and space environmental remote sensing

CONCEPT

- **3 or more orbital planes**
- **Remote Sensing, Surface Data Collection, Search & Rescue Payloads**
- **Utilize existing AFSCN ARTS and NOAA CDA tracking stations**

(or other available relay assets)



Requirements

- **Integrated Operational Requirements Document (IORD-1)**
  - **Establishes 12 system parameters**
  - **Reflects 70 environmental data records (EDRs)**
  - **Preferred alternative addresses 61 of 70 EDRs**
  - **Remaining EDRs are Pre-Planned Product Improvement (P^3I) candidates**

NPOESS Data Products

Environmental Data Records (EDRs)

Data records that contain the environmental parameters or imagery required to be generated as user products as well as any ancillary data required to identify or interpret these parameters or images.

Raw Data Records (RDRs)

Full resolution, unprocessed digital sensor data, time-referenced and annotated with ancillary information including radiometric and geometric calibration coefficients and georeferencing parameters such as platform ephemeris. Ancillary data may be computed, but not applied to the data. Sensor to ground Interface Specifications will define these data.

- Expect contractors to specify in proposals

NPOESS Environmental Data Records (EDRs)

- **An EDR is a product-level definition of an observed or derived parameter**
  - **Product Definition**
  - **Measurement attribute (THRESHOLDS & OBJECTIVES)**
    - **Resolution (horizontal/vertical)**
    - **Measurement accuracy/precision**
    - **Mapping accuracy**
    - **Refresh rate**
    - **Measurement range**

NPOESS
Key Parameters/Thresholds/Objectives

- **Definitions of Major Elements in the IORD**
  - **THRESHOLD: Minimum acceptable to meet mission requirements**
  - **OBJECTIVES: Enhancements that will provide a quantifiable improvement im mission performance (for IORD-1, these provide the baseline for concept/trade-off studies)**
  - **KEY: A requirement of such importance that failure to meet the threshold value would result in a system reassessment/termination**

EDRs Addressed in IORD-1

Vertical Moisture	Electric Fields	Precipitable Water
Vertical Temperature	Electron Density Profiles	Precipitation
Imagery (Clouds and Ice)	Fresh Water Ice	Pressure (surface/profile)
Sea Surface Temperature	Geomagnetic Field	Radiation Belt & Low Energy
Sea Surface Winds	Ice Surface Temperature	Sea Ice Age and Motion
Soil Moisture	In-situ Ion Drift Velocity	Sea Surface Height/Topography
Aerosol Optical Thickness	In-situ Plasma Density	Snow Cover/Depth
Aerosol Particle Size Concentration	In-situ Plasma Fluctuations	Solar EUV Flux
Albedo (surface)	In-situ Plasma Temperature	Solar Irradiance
Auroral Boundary	Ionospheric Scintillation	Solar/Gal Cosmic Ray Particles
Auroral Imagery	Land Surface Temperature	Super Thermal Auroral Particles
Cloud Base Height	Littoral Sediment Transport	Surface Isolation
Cloud Cover/Layers	Long Wave Radiation	Surface Wind Stress
Cloud Ice Water Path	Net Heat Flux	Suspended Matter
Cloud Liquid Water	Net Short Wave Radiation	Total Auroral Energy
Cloud Optical Depth/Transmittance	Neutral Density Profiles	Total Longwave Radiation
Cloud Top Height	Ocean Color/Chlorophyll	Total Water Content
Cloud Top Pressure	Ocean Currents	Turbidity
Cloud Top Temperature	Ocean Wave Characteristics	Upper Atmospheric Airglow
Droplet Size Distribution Index	Ozone Total Column/Profile	Vegetation Surface Type
Effective Cloud Particle Size		

Key Parameters in Bold

NPOESS
Notional System to Satisfy IORD-I

USG Payloads	0530	1330	EUM**
VIS/IR Imager/Radiometer w/Ocean Color	X*	X*	X*
Low-Light VIS Imager	X	X	X
Cross-track IR Sounder		X*	
Cross-track MW Sounder		X*	X*
Conical MW Imager/Sounder	X*	X*	X*
Ozone Profiler/Monitor		X	
Data Collection System	X	X	X
Search & Rescue	X		X
Space Environmental Suite	X	X	X
Earth Radiation Budget Sensor		X	
Solar Irradiance Sensor	X		
Altimeter	X		
Survivability: Laser and Jamming			
* Assumed Critical Payload			
** Assumes European IR sounder (IASI) included			

Unaccommodated Needs/P^{3}I Candidates

- **Proposed EDRs that have <u>not</u> been included in NPOESS baseline, requirement set selected by SUAG based on COBRA assessment of cost and/or lack of technical maturity, but will be studied by IPO during Phase I**

Tropospheric Winds	Enhanced Ozone
CH_4 Column	CO Column
CO_2 Column	Optical Backgrounds
Bathymetry	Bioluminescence
Salinity	

Conditions for Supplying NASA Research Instruments to the Convergence Operational (NPOESS) Platform

Appendix 1 to NPOESS MOA

"If the decision is made to fly a NASA instrument on the (NPOESS) platform instead of continuing to fly it on a NASA research spacecraft, because the research instrument will meet the convergence operational requirements in a cost-effective manner and continues to provide data so as to fulfill primary NASA research mission requirements, NASA will provide additional copy(s) of the instrument for flight on the NPOESS platform at no unit cost to the NPOESS program. This policy of supplying instruments at no cost will apply as long as NASA continues to need the data supplied by the instrument to fulfill its primary research mission objectives. ..."

Potential Operational/Scientific Measurements of Common Interest Between EOS and NPOESS

- **NPOESS Integrated Program Office (IPO) has published updated Integrated Operational Requirements Document (IORD-1)**
- **EOS investigators currently reviewing IORD to identify common measurement interest**
- **Initial Examination of EOS/NPOESS for common objectives shows the following:**
  - atmospheric temperature and humidity profile (IR & Microwave)
  - Total solar irradiance (active cavity radiometer)
  - Clouds and radiation properties (Cloud imaging radiometer & broad-band scanning radiometer)
  - Ocean color (ocean surface imager)
  - Ocean-surface topography (radar altimeter, water vapor radiometer & high precision orbit determination)

Case Study
Atmospheric Vertical Temperature Profile
- Key Attributes -

Measurement Accuracy

	NPOESS	NPOESS	EOS*
Clear	**Threshold**	**Objective**	
Surface to 300 mb*	1.6 °K/1 km layer	0.5 °K/1 km layer	1.0 °K/1 km layer*
300 mb to 30 mb	1.5 °K/3 km layer		
30 mb to 1 mb	1.5 °K/5 km layer		
1 mb to 0.01 mb	3.5 °K/5 km layer		
Cloudy			
Surface to 700 mb	2.5 °K/1 km layer		
700 mb to 30 mb	1.5 °K/1 km layer		
30 mb to 1 mb	1.5 °K/5 km layer		
1 mb to 0.01 mb	3.5 °K/5 km layer		

*EOS (Surface to 100 mb)

Case Study
Atmospheric Vertical Moisture Profile
- Key Attributes -

Measurement Accuracy

(over Ocean)	NPOESS Threshold	NPOESS Objective	EOS*
Clear			
Surface to 600 mb*	25%	10%	20%*
600 mb to 400 mb	35%		
400 mb to 100 mb	35%		
Cloudy			
Surface to 600 mb	25%		
600 mb to 400 mb	40%		
400 mb to 100 mb	40%		

(Precipitable H_2O in 2 km layers)

*EOS (Surface to 100 mb)

Case Study
Imagery (Clouds & Ice)
- Key Attributes -

	NPOESS Threshold	NPOESS Objective	EOS
Horizontal Resolution			
Regional			
At nadir	0.4 km		0.25, 0.5, 1 km (2, 5, 29 bands)
Worst Case	0.8 km	0.1 km	0.50, 1.0, 2 km (2, 5, 29 bands)
Global			
At nadir	1.0 km		same as Regional
Worst Case	2.4 km	0.65 km	same as Regional
Nighttime visual	2.6 km	0.65 km	No Requirement
Refresh	4 hours	1 hour	12 hours

Case Study
Sea Surface Temperature
- Key Attributes -

	NPOESS Threshold	NPOESS Objective	EOS
Horizontal Resolution			
Regional, nadir	1 km	0.5 km	1 km
Regional, Worst Case	1.3 km		
Global, nadir	3 km	1 km	1 km
Global, Worst Case	4 km		
Measurement Accuracy	0.5 °C	0.1 °C	0.3-0.5 °K
Refresh	6 hours	3 hours	24 hours

Case Study
Sea Surface Winds
- Key Attributes -

	NPOESS Threshold	NPOESS Objective	EOS
Horizontal Resolution	20 km	1 km	50 km
Mapping Accuracy	5 km	1 km	
Measurement Range	3-25 m/s, 0-360°	0-25 m/s, 0-360°	3-30 m/s, 0-360°
Measurement Accuracy			
Speed	2 m/s or 20%	1 m/s or 10%	1.5 m/s or 10-12%
Direction	20°	10°	20°
Measurement Precision			
Speed	1 m/s	1 m/s	
Direction	10°	10°	
Refresh	6 hours	1 hour	48 hours

Case Study
Soil Moisture
- Key Attributes -

	NPOESS Threshold	NPOESS Objective	EOS
Sensing Depth	surface to -0.1 cm	surface to -80 cm	TBD
Horizontal Resolution			
Clear, nadir	1 km		
Clear, worst case	4 km	2 km	
Cloudy, nadir	40 km	2 km	
Cloudy, worst case	50 km		
Mapping Accuracy	3 km	1 km	
Measurement Accuracy	Bare soil		
in regions with known soil		surface: 1 cm/m	
	10 cm/m	column: 5%	
	20 cm/m	or 130 g/m^3	
Refresh	8 hours	3 hours	

Baseline OMIS/VIRSR Requirements - Spectral Bands

LOCKHEED MARTIN

Spectral Bands (μ m)	HSR (km)	Sensor	Low Cost	Baseline	Enhanced
0.605 - 0.625	0.65	SS	X	X	X
0. 860 - 0.880	0.65	SS	X	X	X
6 Visible Ocean Color Bands	1.3	SS		X	X
1.54 - 1.66	0.65	SS	X	X	X
2.07 - 2.17	0.65	SS			X
2.28 - 2.38 (CH_4 Gas cell)	100	SS			X
2.37 - 2.47 (CO Gas cell)	100	SS			X
3.53 - 3.93	0.65	SS	X	X	X
8.4 - 8.7	0.65	SS		X	X
10.5 - 11.5	0.65	SS	X	X	X
11.5 - 12.5	0.65	SS	X	X	X
0.4 - 1.0	0.65	LL	X	X	X

NPOESS PHASE 0 CONCEPT EXPLORATION & DEFINITION

OASIS REQUIREMENTS (2 OF 3)
- SUMMARY of KEY DERIVED REQUIREMENTS -

npoess LOCKHEED MARTIN

FROM EM # 1165 "EDRs AND ALGORITHMs: REMOTE SENSING REQUIREMENTS

PARAG.	PARAMETER	REQUIREMENT	ESTIMATE	UNITS	COMMENTS
1.1	SPECTRAL BANDS				
	Channel 1	0.60 - 0.64	0.60 - 0.64	μm	VIS 1
	Channel 2	0.85 - 0.89	0.85 - 0.89	μm	VIS 2
	Channel 3	1.51 -1.75	1.51 -1.75	μm	SWIR
	Channel 4	3.55 - 3.93	3.55 - 3.93	μm	MWIR
	Channel 5	10.3 - 11.3	10.3 - 11.3	μm	LWIR1
	Channel 6	11.5 - 12.5	11.5 - 12.5	μm	LWIR2
	Channel 7	0.4 - 1.0	0.4 - 1.0	μm	NIGHT-TIME VISIBLE CHANNEL
	Channel 8	8.4 - 8.7	8.4 - 8.7	μm	LWIR3
1.1	RANGE				
	CH 1-3	1.3E-04 - 2.65E-02	1.3E-04 - 2.65E-02	W/cm2/SR	IN AN EQUIVALENT 0.4 -1.0 μm BAND
	CH 4	240 - 340	240 - 340	K	
	CH 5-6	190 - 340	190 - 340	K	
	CH 7	4E-09 - 1.3E-04	4E-09 - 1.3E-04	W/cm2/SR	
	CH 8	225 - 340	225 - 340	K	
1.1	SNR/NEΔT				
	CH 1 SNR	10	14	-	@ 0.5% ALBEDO
	CH 2 SNR	10	12.3	-	@ 0.5% ALBEDO
	CH 3 SNR	10	22.1	-	@ 0.5% ALBEDO
	CH 4 NEΔT	0.1	<0.1	K	@ 300K
	CH 5 NEΔT	0.1	<0.1	K	@ 300K
	CH 6 NEΔT	0.1	<0.1	K	@ 300K
	CH 7 SNR	6	6	-	ESTIMATE FOR LLL NADIR FOOTPRINT = 3.25 km
	CH 8 NEΔT	0.1	<0.1	K	@ 300K

EOS/NPOESS Commonality Issues to be Resolved During NPOESS DEM/VAL

- **OBSERVATION REQUIREMENTS:** ***Spatial resolution (horizontal and vertical), refresh rate (frequency of observation), orbit and nodal crossing time, calibration (absolute and relative), data continuity***
- **INSTRUMENT CHARACTERISTICS:** ***Spectral selection and resolution, scan geometry (i.e.; cross track, biaxial, conical, constant resolution), signal/noise, scan rate, lifetime***
- **INSTRUMENT ACCOMMODATION:** ***Size, mass, fields of view, power, thermal, pointing, data storage, data downlink***
- **Synergism Requirements With Other Sensors**
- **Ground System/ Data Processing Requirements**
- **Cost and Availability**